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Developing CAD-Based Learning Module on Manufacturing Engineering Drawing

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Abstract: This research aims to develop a learning module on Manufacturing Engineering Drawings that are interesting and appropriate for use in learning, to learn the practicality of module in the learning process, and to find out the learning module in improving student learning outcomes. The design of research and development used as a 4D (Define, Design, Develop, and Dissemination) development model. The results obtained from the study of this development as follows: (1) to generate a Computer-Aided Design (CAD)-based learning module, (2) the validity of the module was declared valid by media experts (0.89), subject matter experts (0.88), and linguists (0.85), (3) based on the response of teachers, the module was very practical (90.64 %) and based on student's responses, the module was declared as very practical (84.65 %), (4) the module was declared effective and can improve learning outcomes of students. Based on the findings of this study, it can be concluded that the developed learning module is valid, practical, and effective to be used as a learning module in Manufacturing Engineering Drawing.

INTRODUCTION

The challenges of the globalization era in the world of education are currently growing rapidly (Ciffolilli & Muscio, 2018; Jima'ain, Mahpuz, Rahman, & Mohamad, 2019; Subekti, Taufiq, Susilo, Ibrohim, & Suwono, 2018), namely with the development of modern science and technology (Dewi, 2019; Suprpto, 2018). In facing this development, it is necessary to have the best facilities to produce competent graduates (Abidin, 2017; Ahmad, Yakob, & Ahmad, 2018). One of them is by using effective teaching materials (Rahmi, 2019). Especially for vocational students who need teaching materials such as learning modules

(Syihab & Ali, 2018), which can improve the drawing techniques (Fernandes, Syahril, & Waskito, 2019; Kurniawan, Nopriyanti, & Sucipto, 2018).

Engineering drawing is a tool to express the ideas or ideas of technical experts (Amri & Sumbodo, 2018; Putra, I Nyoman Pasek Nugraha, S.T., & Kadek Rihendra Dantes, S.T., 2018; Wahyudi, Widiyanti, & Nurhadi, 2018). One of the abilities that must be possessed by people working in the world of engineering is the engineering drawing ability (Ardiansyah, Yoto, & Sumarli, 2017; Lestari & Basuki, 2018). Therefore, engineering drawing must be in accordance with the right and correct criteria (Ihsan & Efendi, 2018).

Along with the development of science and technology, engineering drawings can be done using Computer-Aided Design (CAD) software (Li, Lange, & Ma, 2018; Priono, Purnawan, & Komaro, 2019). CAD is a program used in engineering drawing (Bisono & Hendarti, 2019; Gembarski, Li, & Lachmayer, 2017). CAD is simply used to design and draft with the aid of a computer (Shisir, Manjunath, Pavanasadu, & Sathyajith, 2015; Zhang & Zhou, 2019). Design is creating a real product from an idea. Drafting is the production of the drawing that is used to document a design (Hatwar, Bargat, & Bohra, 2016). CAD can be used to create 2D or 3D computer models (Kamiel, Nugraha, & Sunardi, 2018). CAD can be interpreted as designing and drawing (drafting) with the assistance of computers. The use of CAD will cover the entire design process and can be accommodated quickly and cheaply. So, the industry will be more effective and efficient in the design process. In the industrial world today, CAD is increasingly trusted to help design products (Bisono & Hendarti, 2019; Seppala & Migler, 2016). Many CAD programs are used in the industrial world, including AutoCAD, Solidworks, Autodesk Inventor, Catia, and so on (Lingenfelter & Rew, 2019).

Responding to the challenges of the industrial world as well as technological advancements, capabilities in the automotive, manufacturing, and heavy equipment machinery fields are needed (Suyanto, 2016). To improve these competencies, engineering drawings can be done with a CAD system using Autodesk Inventor Professional (Purnomo & Wijanarka, 2017). Autodesk Inventor is a software specifically designed for engineering, for example: designing products, designing machines, designing molds, designing constructions, and other technical needs (Achmad, 2016). Also, Autodesk Inventor is a product intended

for engineering and drawing which can create 3-dimensional objects visually, simulating, drafting, and documenting its data (Sunardi, 2017). By using this application, a person who draws can make 2-dimensional (2D) sketches of the product and then model it into 3 dimensions (3D) which are used for making visual prototypes or simulations that are more complex (Jahidin, 2013).

However, based on the results of observations made by researchers in June 2019 at SMK 1 Padang, the learning process of Manufacturing Engineering Drawings, which have been carried out in the classroom, were still dominated by lectures using the projector to achieve technical drawing skills. After the theoretical learning had been done, the teacher assigned assignments to the students. learning like this is only centered on the teacher. Thus, students' interest in drawing techniques was still weak and caused students often do not understand the tasks given by the teacher.

The students' difficulty impacts their learning outcomes, where student grades tend not to be optimal. Of the 34 students in the class, 14 students have not reached the Criteria of Minimum Mastery (KKM). This can be seen in Table 1.

Table 1. The Learning Outcomes of the Eleventh-Grade Mechanical Engineering Students at SMK Negeri 1 Padang

No	Interval Score	Number of students
1	80-100	20
2	60-79	10
3	10-59	4

Source: Documentation of Mechanical Engineering Vocational Program at SMKN 1 Padang.

The effort to overcome this problem is the use of interactive teaching materials such as module (Kurniawan, Nopriyanti, & Syofii, 2018). The module is a learning tool or facility in the form of materials, methods, and evaluations that are made systematically and structured to achieve the competency goals needed based on

each student's understanding (Kurniawan, Nopriyanti, & Sucipto, 2018).

Research on the application of module as learning in engineering drawing has been carried out by previous studies, including (Utomo, 2013), who suggests that the development of Auto CAD module on mechanical engineering drawing in local content competence is very effective for learning. Then, (Husin, 2012) also explains that the development and application of the work safety learning module (K3) for Students has been tested for its quality and suitability to be used in the learning process. Furthermore, (Syahbana, 2013) states that the development of learning courses for occupational safety and health (K3) is declared valid and is suitable for use as a learning guide.

However, there is still very little research on developing a CAD-based learning module. The need for a learning module using Autodesk Inventor software in Manufacturing Engineering Drawings can simplify the learning process (Muriman, 2014). For this reason, this study aims to develop a CAD-based learning module in Manufacturing Engineering Drawings and reveal the validity, practicality, and effectiveness of CAD-based learning modules in Manufacturing Engineering Drawings.

METHOD

This research employed the Research and Development design. This study used the 4-D development model that consisted of 4 stages, namely, Define, Design, Develop, and Disseminate. The subjects of this study were the eleventh-grade students of engineering major of SMKN 1 Padang, with a total of 17 students and only 1 class.

The primary data of this study was obtained directly by researchers through

the results of the validation of the learning module conducted by the experts. The data generated from the implementation of the pilot class is the students' response toward the Manufacturing Engineering Drawing module that was developed after the product was tested (practicality) and students' learning outcomes of the cognitive aspects (effectiveness).

The Define stage consisted of five steps of analysis, namely: observation analysis, student analysis, task analysis, concept analysis, and formulation of learning objectives. The sources of data were obtained from students and teachers. Furthermore, at the Design stage, the CAD-based module was designed by considering the previous stage to suit the needs of students. The development of modules to be designed included the following matters: format selection, compatibility between material and syllabus, module design, arranged according to the syllabus requirements of Manufacturing Engineering Drawing, Grammar used is easy to understand, and the way of presenting material that influences development CAD-based learning module.

After completing the design stage, the next stage was Develop. At this stage, the CAD-based learning module was validated by media experts, material experts, and linguists. After the module validation was done, the next step was the product trial to find out the responses of students and teachers toward the developed CAD-based module. The next stage was disseminate. At this stage, the module was distributed to the other classes aimed at finding out the effectiveness of the module in the learning process.

The following is the flowchart of the 4D development model:

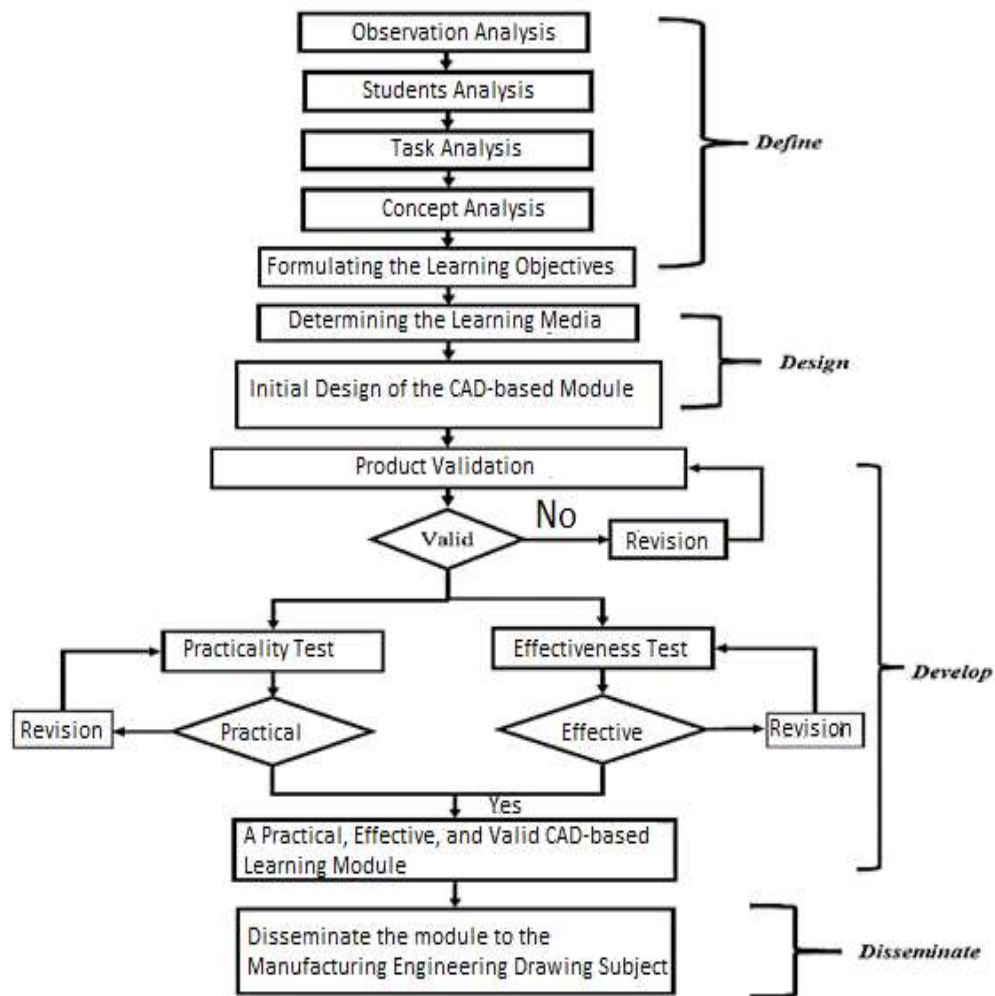


Figure 1. The 4-D Development Model

To determine the validity value, Aiken's V statistical formula was used to calculate the Content Validity Coefficient based on panel rating experts as many as n people on an item regarding the extent to which the item represents the measured construct. Furthermore, the average score was calculated by the following steps:

$$V = \sum S / [n(c - 1)]$$

Note:

V = Validity Index

S = $r - lo$

n = Number of validators or panel evaluators

lo = Lowest validity rating (= 1)

c = The score for highest validity assessment (= 5)

r = The score given by a validator

The range of numbers "V" obtained between 0 to 1.00 so that for a range of \geq

0.667 can be interpreted as high and can be categorized as valid. The method to determine the validity of the developed CAD-based module can be seen in Table 2.

Table 2. Validity Level Criteria

Category	Qualification
0.67 – 1.00	Valid
≤ 0.66	Invalid

RESULT AND DISCUSSION

Manufacturing engineering drawing has become a prerequisite lesson in the Mechanical Engineering vocational program. One of the competencies that must be achieved is a detailed drawing of machine components with 2D CAD. These competencies include understanding how to draw machine

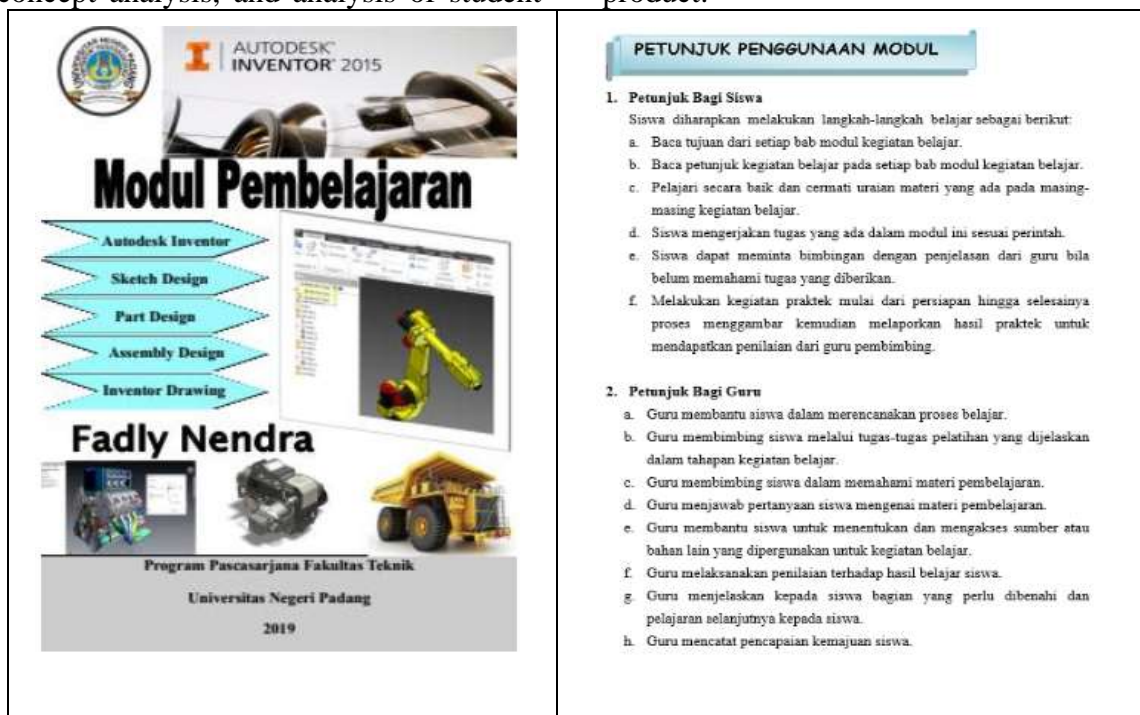
components, presenting the drawing area, and presenting 2D CAD drawing output.

Seeing the learning characteristics of the Manufacturing Engineering Drawing, the development of the learning module is quite potential to meet the demands of the competency. The use of interactive learning modules can facilitate navigation, display videos, animations, and images. (Suarsana & Mahayukti, 2013). The strengths of the learning module are updating existing teaching materials, providing students' understanding and motivation, and with the help of Autodesk Inventor software, the students can understand the material and increase their motivation in carrying out learning. However, very little research has been done on the development of such a learning module. The learning module needs in Manufacturing Engineering Drawings can simplify the learning process.

The process of developing the learning module was started from the process of preliminary analysis, design, and assessment. In the preliminary analysis stage, several activities were carried out, namely syllabus analysis, concept analysis, and analysis of student

characteristics. This stage was done as a basis for developing a learning module on the Manufacturing Engineering Drawing subject so that it can be used to facilitate students in understanding the material. After carrying out the preliminary analysis stage, the learning module can be used to accommodate basic competences 3.6 and 4.6, which is understanding and presenting detailed drawings of machine components with 2D CAD.

This basic competency is divided into several indicators, namely understanding the making of detailed drawings of machine components with CAD 2D, analyzing the drawing area, evaluating the output of 2D CAD drawings, presenting detailed drawings of machine components with 2D CAD, presenting the drawing area, and presenting 2D drawing of CAD drawings. This learning module will later be printed. This learning module contains material, practice exercises, discussion forums, and learning videos. After the learning module had been developed, the validity, practicality, and effectiveness of the learning module were tested. The following is the printed form of the product:



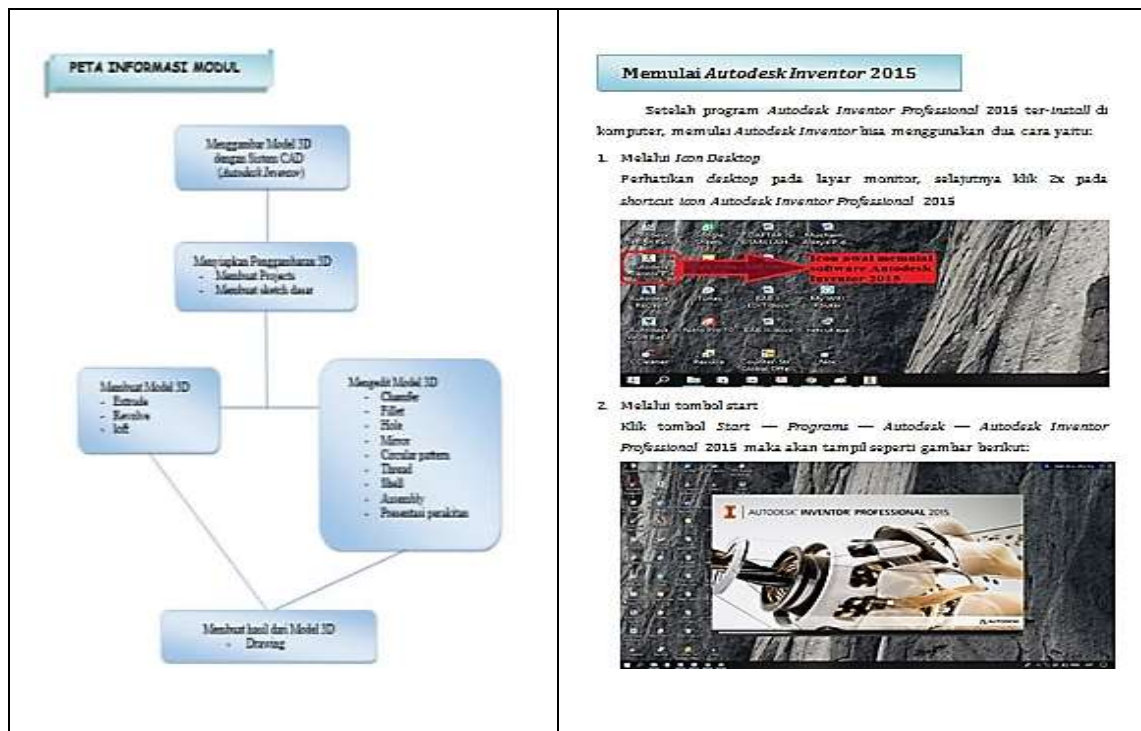


Figure 2. Some Components of Module

The developed module was then validated by the validators. Validation was carried out by five validators. In this activity, experts were asked to assess the module that had been made. The assessment included the material aspects by validator I and validator II, the media aspects by validator III and validator IV, as well as language aspects by validator V. The validators were asked to provide assessments and suggestions for improvement of the module.

Media Expert Validation

Media validation is the validation of the product. Media validation was carried out by two validators of media experts. The media validation consisted of four aspects of assessment, namely assessment of language aspects, presentation aspects, aspects of media effects on learning, and overall aspects.

Evaluation results from each aspect were analyzed using Aiken's statistical formula. The results obtained were the validation scores of the product design produced. The results of the validation are shown in Table 3.

Table 3. Results of Media Expert Validation

No	Aspect of Evaluation	Validator I	Validator II
1	Language	0.83	0.92
2	Presentation	0.83	0.92
3	Media Effects	0.90	0.95
4	Overall Display	0.91	0.88
	Average	0.87	0.92
Total Average		0.89	
Category		Valid	

Based on Table 3, the validation results show that this module has a validity value of $0.87 \geq 0.66$ given by validator I, a validity value of $0.92 \geq 0.66$ given by validator II. Thus, the CAD-based module is included in the valid category. In accordance with the opinion of Achmad (2016), where the printed module must consider the quality and quantity of media display so that it is easy to read (Achmad, 2016).

Material Expert Validation

The validation was carried out by two validators of the Manufacturing Engineering Drawing subject. The purpose of this validation was to determine the accuracy and suitability of the material contained in the CAD-based

module, whether it is by learning needs. The validation was carried out by material experts in terms of material aspects, presentation aspects, and overall appearance aspects. Evaluation results from each aspect provided by the validator were then analyzed using the Aiken's V statistical formula. The results obtained are presented in Table 4.

Table 4. The Results of Material Expert Validation

No	Aspect of Assessment	Validator III	Validator IV
1	Language	0.88	0.90
2	Presentation	0.83	0.92
3	Display	0.88	0.91
	Average	0.86	0.91
Total Average		0.88	
Category		Valid	

Based on Table 4, the CAD-based learning module has a validity value of $0.86 \geq 0.66$ given by the Validator III, the validity value of $0.91 \geq 0.66$ given by the Validator IV, the material in the CAD-based module is included in the valid category.

Linguist Validation

Expert validation by a linguist is a validation of the correct use of the module's languages. This language validation was carried out by one linguist with four aspects; straightforwardness, communicative and interactive aspects, conformity to language rules, and use of terms. The results of the validation are shown in Table 5.

Table 5. The Results of Linguist Validation

No	Aspect of Evaluation	Validator V
1	Straightforwardness	0.94
2	Communicative and interactive	0.81
3	Conformity with language rules	0.75
4	Use of terms	0.92
Average		0.85
Category		Valid

Based on Table 5, the language used in the CAD-based module has a validity

value of $0.85 \geq 0.66$ given by validator V. The language in the CAD-based module is included in the valid category.

Based on the description of some of the overall validation, the results of the CAD-based module validation can be seen in Figure 2.

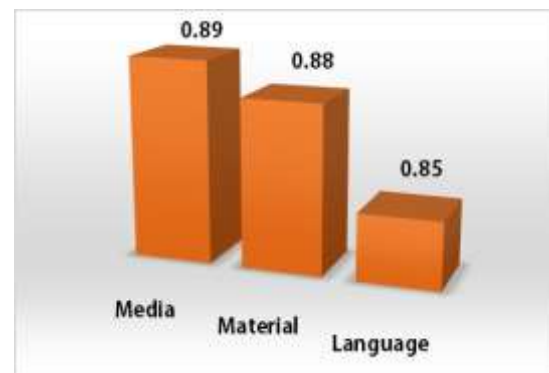


Figure 3. Overall Module Validation Result

Based on the analysis results displayed in Figure 3, the overall validation value of the module is $0.87 \geq 0.66$ and is included in the valid category. So, it can be concluded that the developed CAD-Based module in Manufacturing Engineering Drawings is valid.

Furthermore, after the module has been validated, a field trial was conducted to see the practicality of the CAD-based module. The respondents who rated the practicality of the CAD-based module were subject teachers and students. The practicality data based on teacher's responses are summarized in Figure 4.

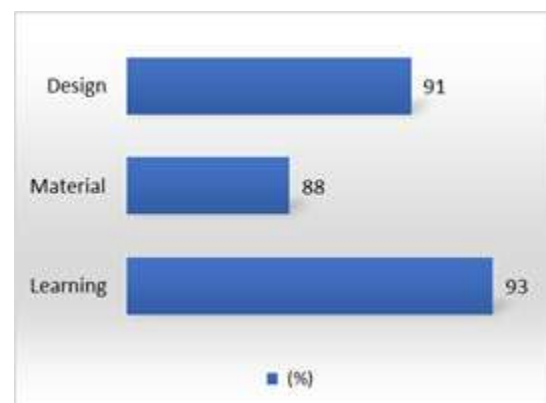


Figure 4. Teacher's Responses toward the Module's Practicality

Based on Figure 4, the average practicality value of the CAD-based module from the teacher's response is 90.64 %. So, it can be concluded that the module is included in the very practical category. The representation of the data shows that the use of CAD-based module is very helpful for teachers in implementing the learning process.

Practicality test data based on students' responses is to measure students' responses toward the practicality of the CAD-based module. The results of students' practicality assessment are displayed in Figure 5.

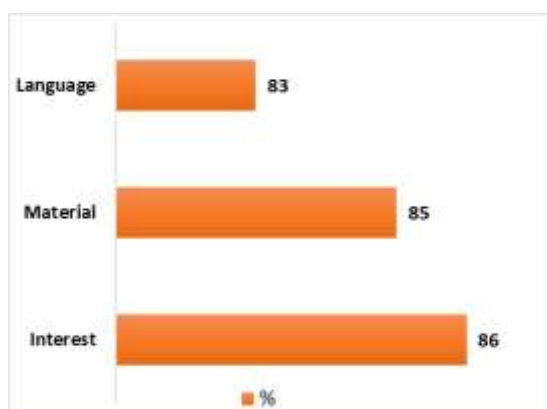


Figure 5. The Result of Students' Responses on Module's Practicality

Based on Figure 5, the average results of the practicality value of the CAD-based module are 84.65 %. So, it can be concluded that the CAD-based module is included in the very practical category. The representation of the data shows that the use of CAD-based module is very helpful for students in the learning process.

Based on the results of a questionnaire analysis, it can be concluded that the learning module designed in this study can be read and understood clearly by students and teachers, are easy to use, and that students are interested in using the module. This is in accordance with the opinions of (Salimin, Samhuddin, & Adha, 2018), who state that the material in a module developed could be made as attractive as possible so that it can be used easily for the achievement of learning objectives.

Finally, the effectiveness of the learning module was tested by comparing the results of the pretest and posttest. The results of the analysis to determine the pretest and posttest data distribution is contained in Figure 6 and Figure 7.

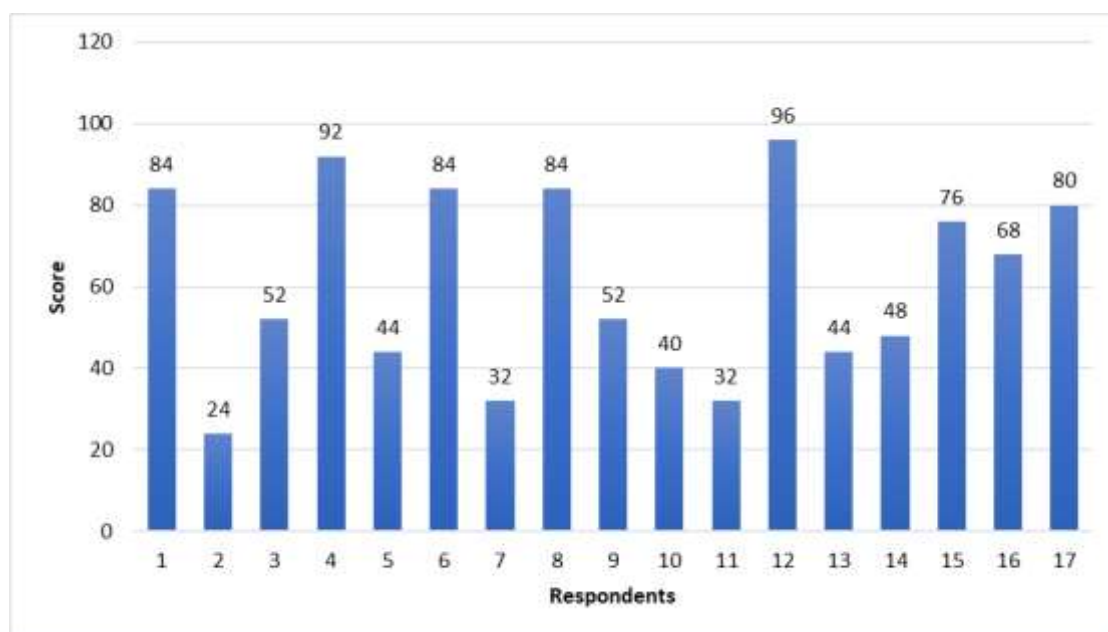


Figure 6. The Results of Pretest

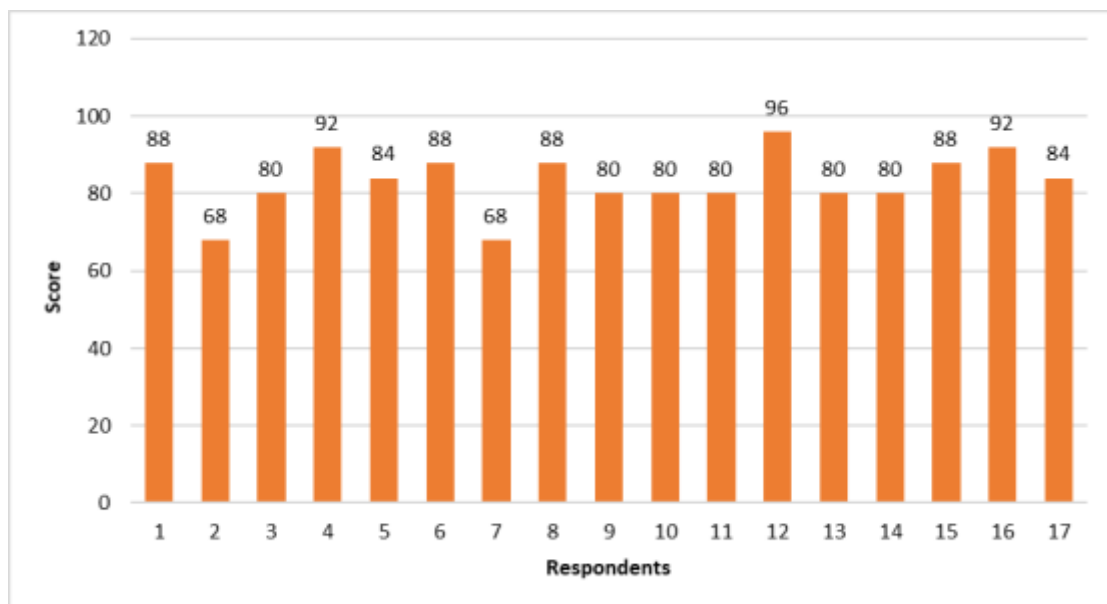


Figure 7. The Results of Posttest

Based on Figure 6 and Figure 7, the average score obtained in the pretest was 60.71, and the average score obtained in the posttest was 83.29. From the results of the assessment, there was an increase in learning outcomes. Based on the results of the posttest, it was found that the student learning outcomes reached the minimum mastery (KKM) which is 83.29 %. So it can be concluded that the developed module is easy to use in the learning process.

The effectiveness of the learning module was taken from the learning outcomes based on the 2013 curriculum. Students' learning outcomes consist of three domains, namely the assessment of attitudes, knowledge, and skills. Based on the three assessments above, it can be concluded that the learning outcomes through the module has been completed.

Table 6. The Effectiveness Test in Terms of Learning Outcomes

Evaluation Aspect	Average Aspect
Attitude Assessment (Affective)	3.28
Knowledge Assessment (Cognitive)	3.20
Skills Assessment (Psychomotor)	3.15
Average	3.21

The effectiveness of this module also can be seen from the affective, cognitive, and psychomotor aspects in Table 6 after using the developed module. Based on the data analysis, the average result of the module's effectiveness on learning outcomes is 3.21 with a very effective category. Thus, the learning module can be said to be effective. From these assessments, it appears that the students are having motivation, active in learning, creative, and independent in solving problems so that their competencies are optimal. In line with the results of research by (Sugianto, Abdullah, Elvyanti, & Muladi, 2013) that the learning module is considered to be able to increase motivation, interest, and learning activities.

CONCLUSION

Based on the results of the study, it was found that the learning module in Manufacturing Engineering Drawings has been successfully developed using the 4D model, making it feasible to be used in the learning process. Also, students' and teacher's responses toward the learning module are very practical and very

effective. Thus, it can be concluded that the developed learning module could be used to improve competitiveness in the manufacturing industry.

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